PLTW Engineering Big Concepts

The Project Lead The Way Engineering pathway exposes students to concepts that are reflective of knowledge, skills, and abilities necessary to become a successful engineer. As part of the PLTW experience, students learn these big concepts by working through engaging and real-word experiences. The 11 PLTW Engineering Big Concepts include Career Awareness, Collaboration, Communication, Computational Thinking, Design Process, Ethics, Experimental Design, Modeling, Physical Properties, Project Management, and Systems Thinking. Below you will find a description of each concept. Activities in your PLTW Fundamentals of Engineering course incorporate these big concepts, so be prepared to refer to this document as a reference while you complete the course.

Career Awareness

PLTW Engineering coursework engages students in authentic experiences that translate career awareness and exploration into career preparation. PLTW coursework demystifies how engineers develop and leverage skills, knowledge, technology, and mindsets to be successful in their field. Students can see the relevance of the in-demand, transportable skills they develop through PLTW course experiences, which empowers and inspires them to make informed decisions related to career planning.

As a PLTW teacher, it is important that you:

- Provide authentic and diverse examples of industry professionals and career paths that enforce career and college readiness.
- Connect with professionals and industry experts to grow capacity in content knowledge, stay abreast of current and future trends, and identify opportunities for classroom connections.
- Implement pedagogical practices and curriculum knowledge to engage students in career planning.
- Leverage partnerships with parents/guardians, guidance counselors, and administrators to encourage student career success.

Collaboration

It is estimated that 60%–80% of an engineer's time is spent in technical collaboration. Collaboration is the action of two or more people working together through idea sharing to accomplish a common goal. Collaboration includes teamwork and incorporates other aspects,

such as valuing different perspectives, treating everyone as equals, and efficiently sharing work responsibilities. All professionals use collaboration strategies in their day-to-day operations, and employers consistently seek employees who are effective collaborators.

As a PLTW teacher, it is important that you:

- Build learner capacity to collaborate in both in-person and virtual environments.
- Organize the learning environment to support collaborative learning.
- Develop students' interpersonal and group skills, which can be used to resolve conflicts when they arise.
- Build individual and collective accountability for collaborative learning.

Communication

Communication in a PLTW classroom includes developing active listening skills, building and delivering effective presentations, and using an engineering notebook to communicate ideas. Active listening and interpreting is a skill that allows you to process and make sense of what is communicated so you do not miss important information. Building and delivering effective presentations includes identifying your audience, constructing engaging content, and planning an organized delivery. An engineering notebook allows you to formally document the work you perform related to a specific design project. It should be clear and complete so that someone unfamiliar with the work could take over the project without additional information. Some notebook best practices include using a bound notebook, writing in ink pen, and documenting all steps of the design process.

As a PLTW teacher, it is important that you:

- Use technology tools to support development of group work and communication.
- Examine a range of classroom management techniques to encourage a positive learning environment.
- Create a physically and emotionally safe learning environment that is conducive to open and constructive collaboration.

Computational Thinking

The International Society for Technology in Education (ISTE) and Computer Science Teachers Association (CSTA) define computational thinking as a problem-solving process that involves a number of characteristics, such as:

- Formulating problems in a way that allows the use of computer applications and other tools to assist in solving them.
- Logically organizing and analyzing data.

- Representing data through models and simulations.
- Automating solutions through algorithmic thinking.
- Analyzing and implementing potential solutions by identifying the most efficient and effective combination of steps and resources.

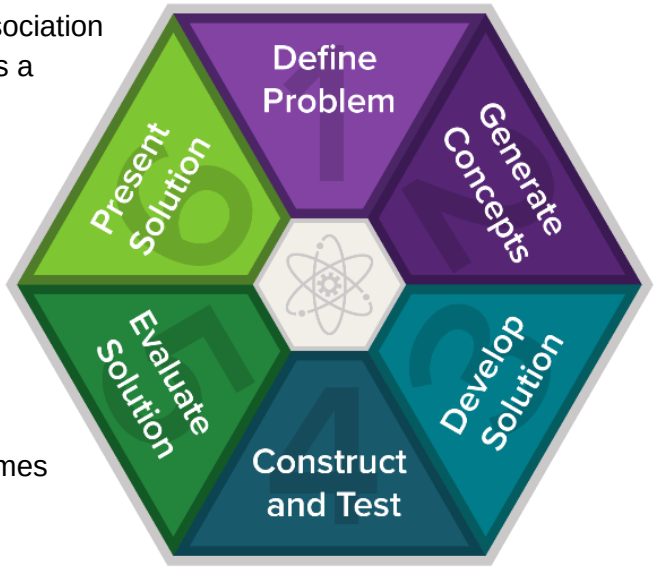
Computational thinking does not just apply to computer science courses; it can be applicable to any subject or course. Consider using computational thinking as a problem-solving process as students work through the Engineering curriculum.

As a PLTW teacher, it is important that you:

- Engage students in generating multiple ideas for solving problems.
- Connect concepts and use differing perspectives to engage learners in critical thinking and problem-solving related to authentic local and global issues.
- Build facilitation skills that promote inquiry and critical thinking.

Design Process

According to the International Technology Education Association Standards for Technological Literacy, a design process is a systematic problem-solving method, with criteria and constraints, used to develop many possible solutions to solve or satisfy human needs or wants. Consistently applying a single clearly defined design process provides a basis for understanding. Project Lead The Way courses use one design process, but it is one of many that exist. It is important to note that the design process is iterative. Designers must evaluate, reflect, redefine, and redesign throughout the process. It is common to repeat steps of the design process several times before an optimal solution is found.



As a PLTW teacher, it is important that you:

- Develop competency in facilitating the use of the engineering design process.
- Create a classroom environment that promotes risk-taking.
- Prepare learners to work through challenges by encouraging them to deal constructively with failures and adversity and embrace them as a learning opportunity.

Ethics

Ethics refers to moral values that affect how a person thinks and behaves. Personal moral values give each person a sense of what is right and wrong and guide them when making decisions. No matter where you go or what you do, you will face *ethical dilemmas*—in school, at work, at home, and with friends. The decisions you make to resolve these dilemmas may affect only a small number of people. Other decisions can have a much greater impact on people and the planet.

Deciding what is acceptable to you often means considering ideas of honesty, fairness, and concern about others and the environment. But not everyone agrees about what is right and fair. Defining a system of moral values—ethical principles—that everyone accepts as good human behavior is not easy.

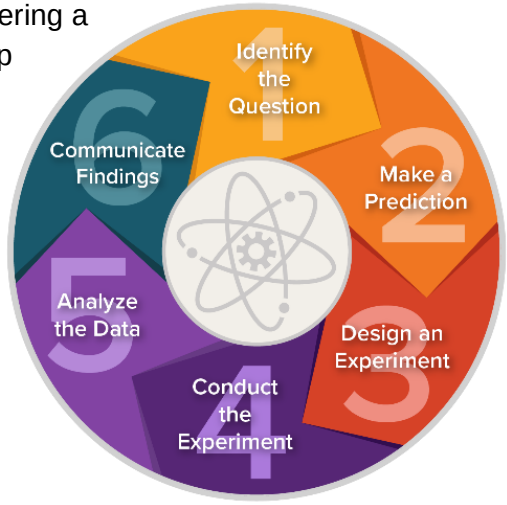
You can apply ethical principles to guide decisions in your personal and professional daily life. However, because each of us has a different personal definition of what is moral and ethical, professional practices require the use of a more consistent code of ethics.

As a PLTW teacher, it is important that you:

- Consider ways to develop students to become responsible consumers of information and technology.
- Coach students to engage in civil discourse about ethical or controversial topics.
- Develop strategies for encouraging students to acknowledge and embrace views that do not match their own.

Experimental Design

An experimental design process is a systematic approach to answering a specific question or to addressing a problem. Experiments can help engineers make decisions, identify design criteria, compare potential solutions, and test a final design. In the design challenge, the experimental design process is used as a guide to help you create a logical, thoughtful, and clearly defined procedure for investigative work.

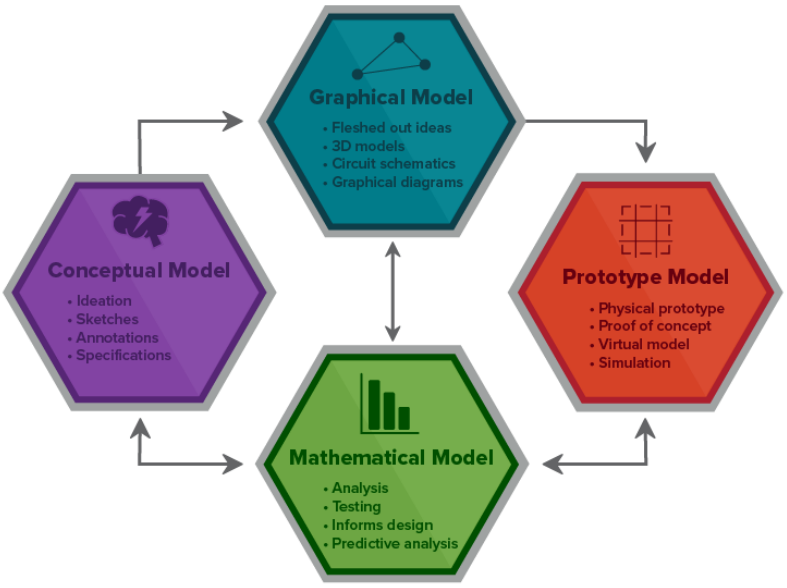


As a PLTW teacher, it is important that you:

- Develop competency in facilitating the use of the scientific inquiry process.
- Invite learners to collaborate in planning their own learning.
- Integrate learner interests and questions into lessons.

Modeling

Modeling is a way to represent an idea or design with a simplified version of the real thing. The resulting model can help you think about and communicate the idea or design. When we simplify something, we remove some of the characteristics or elements that make it complex. We call this simplification *abstraction*. A model is an abstraction of the real thing it represents. Designers and engineers use many types of models. The figure to the right shows different types of models and examples of each type. More than one type of model is often used during a design process.



As a PLTW teacher, it is important that you:

- Model and facilitate effective use of digital tools to promote learning.
- Build understanding of how students use application/transfer of learning to develop solutions to problems.
- Model a mindset of inquiry to develop students' natural curiosity when approaching new material or working through challenges.

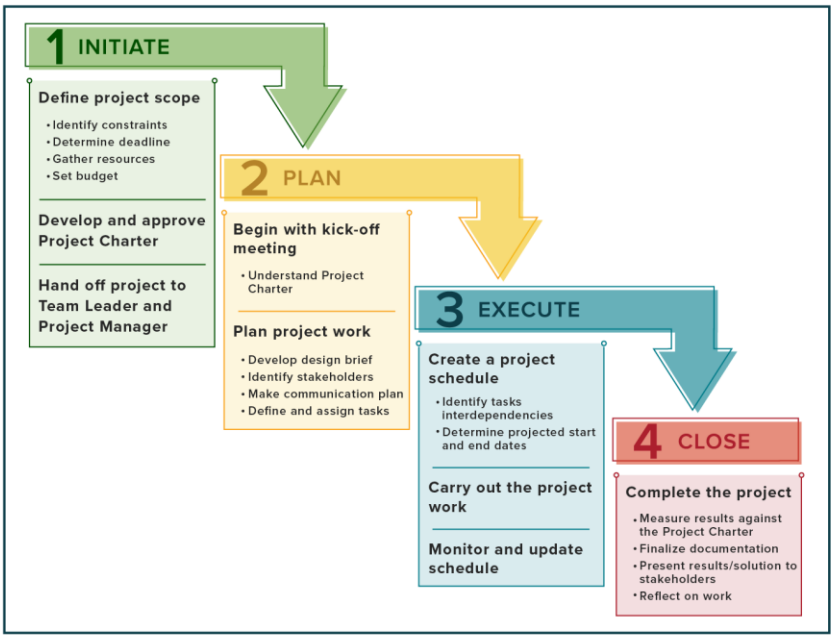
Physical Properties

Physical properties describe or specify an object and can be measured or observed without altering the makeup of the object. For example, if you measure the weight of a marble, observing this property will not change the marble in any way. Other examples of physical properties include color, volume, and density. The physical properties of the materials used throughout the Engineering pathway play a large role in how those scenarios will be approached and solved.

As a PLTW teacher, it is important that you:

- Build expertise in content through continued professional learning.
- Highlight the role of a material's physical properties on its effectiveness in certain applications.
- Encourage students to consider how a material's physical properties can change over time or in different environments.
- Have students think about and research the physical properties of a material when considering improvements in their designs.

Project Management



Projects often require a detailed plan to help the team successfully meet project requirements using the allocated resources in the time available. Developing and implementing a project plan is called project management. Project management involves technical aspects of project planning, such as creating a manageable schedule and budget for the project. It also involves working with people—communicating, leading, resolving conflict, and motivating. Successful project management takes practice and discipline. It is not always easy to work within tight constraints (time, resources, budget) and produce a quality product, but effective project management will help you control the process and improve the final product. The graphic shown above

summarizes the waterfall method of project management. This method is a sequential approach where the team works through defined phases in order. The project phases can overlap, and the sequence can always be repeated to iterate to a solution.

As a PLTW teacher, it is important that you:

- Foster a culture where learners take ownership of their learning and learning environment.
- Allocate and manage time to maximize student learning.
- Develop standards of conduct that teach and build acceptable behavior that is positive and promotes social acceptance.
- Encourage students to start seeing the interconnectedness of individual pieces and a project in terms of tasks, time, and resources.

Systems Thinking

Systems thinking is looking at things as a whole rather than as a jumble of parts. It is the ability to understand how parts connect to make up an entire *system*. We use systems thinking as a framework to empower our minds to break down complex problems into simple ones and then reconnect them again. Systems thinking is important because:

- Everything is interconnected! Every choice affects all parts of the system.
- It enables us to look at problems from different perspectives, resulting in different solutions, and identify different opportunities.
- There are no perfect solutions. Trade-offs must be made.
- It allows us to anticipate the impact of each trade-off so we can minimize its severity or even use it to our own advantage.
- It helps us to identify unintended consequences by thinking deeply about everything that will be affected by a decision.
- It enables us to visualize and model relevant objectives, such as long-term sustainability, product manufacturing, or other processes.

As a PLTW teacher, it is important that you:

- Guide students to understand the positive and negative consequences related to their actions.
- Encourage collaboration to uncover unforeseen ramifications of their actions on a system.

References

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